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Published in:
Computer Communication and Management

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

2011 International Conference on Telecommunication Technology and Applications
Proc .of CSIT vol.5 (2011) © (2011) IACSIT Press, Singapore

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Abstract. Online social networks have become essential for many users in their daily communication. Through a combination of the online social networks with opportunistic networks, a new concept arises: Local Social Networks. The target of local social networks is to promote social networking benefits in physical environment in order to leverage personal affinities in the users' surroundings. The purpose of this paper is to present and discuss the concept of local social networks as a new social communication system. Particularly, the preliminary architecture and the prototype of local social networks are presented as well as possible privacy concerns are identified and discussed. In order to address the arising privacy issues, a new concept called diverged personalities is introduced. This concept is based on presentation of different personalities of the user in different circumstances.

Keywords: Social Communication System, Social Networks, Privacy, Opportunistic Networks, User Personalities.

1. Introduction

The history of communication began with the earliest signs of life. It is challenging to trace the communication range because it is not an area for an isolated specialist and communication matters to a wider variety and range of specializations [1]. However, the basis of the communication is composed of, indisputably and invariably throughout time, the sender and receiver(s). Thus, fundamentally communication has not ever changed; it was only the communication systems that significantly developed. The latest revolutionary discovery in regard to communication systems is the invention of Internet. The creation of Internet reduced the distance between people living in different parts of the world by providing an innovative communication infrastructure. Soon on the basis of this technology new services have been developed, which improved the communication between people. Such initiatives as Orkut[1], MySpace[2] and Facebook[3], called online social networks (in the following referred to as OSNs), share a common characteristic: they enable people to create a virtual social network. Exploiting OSNs, users utilize the last and most powerful available communication system: they, simply, broadcast themselves to the online world [2].

Despite the wide spread of OSNs, the flexibility and sociability of these networks can be questioned. Firstly, the access to OSNs services was not available upon user's demand, as it occurred exclusively while using a desktop computer [3]. Further, the human communication is still highly embedded in the physical contact and closeness, provided by the physical environment. Unfortunately, there is no automated way to facilitate communication in the physical environment, which leads to a sociability issue. Thus, people with shared interests and backgrounds fail to leverage interpersonal affinities for personal benefits [3] [4] [5].

Recently, the flexibility restriction on OSNs has been solved by enabling the OSNs services on mobiles. The real advantage of mobile social networks, if compared to OSNs, is that mobile terminals elevate the freedom of movement while using the applications [6]. Moreover, application of wireless technologies in

[1] http://www.orkut.com
[2] http://www.myspace.com
[3] http://www.facebook.com

mobiles allows data sharing in peer to peer networks with communication links created in ad-hoc manner [7] [8]. Thanks to these technologies, mobile applications enable Opportunistic Networks (in the following referred to as ONs). In ONs, nodes are wirelessly connected and have the possibility to identify each other in a short communication range [9]. However, social information is not handled in ONs. Thus, ONs themselves do not represent a solution for the sociability limitations in physical meetings, but they can be considered as a tool to resolve such constraints [10].

In this paper, we define a new communication system, called local social network, which is an integration of OSNs with the ONs. Local social networks target at developing possible advantageous relationships such as friendships, partnerships, business relations by exchanging personalized profiles during physical meetings. Local social networks can be seen as a solution for the sociability limitation in physical meetings due to facilitation of face to face interaction between neighbours. Furthermore, we present a preliminary architecture and a first prototype of the local social networks as well as discuss related benefits and issues. Finally, we also introduce a new concept called diverged personalities, which is expected to preserve users' privacy in local social networks communication system.

2. Related Work

In the past there have been attempts to make ONs sociable. However it is still a very young approach and needs to be further investigated [11]. The first research of sociable ONs was based on a centralized architecture. MIT's Serendipity project [3] was the pioneer of using a centralized server in order to promote users' interactions in physical proximity based on users' similarities. Nicolai et al implemented a mobile application for analysis of personal social networks, called The Wireless Rope [12]. All the information collected by this mobile application is stored in a database and available on the website for further exploration. Thus, users are able to investigate their neighbourhood and identify the relations with other users in their proximity. In MobiSoc [5], when peers meet opportunistically, the application captures, manages and shares the social state of physical communities. The social state is composed of people profiles, people to people affinities and people to places affinities. MobiSoc exploits learning algorithms to notify users about matches with their preferences. Differently from the projects discussed above, other mobile social networking applications like Aka-Aki[4] and Nokia Sensor [7] do not depend on a central architecture, but they rely exclusively on opportunistic connections between neighbouring devices. Using the Bluetooth technology, they are able to discover other users within a short range and exchange contents like local profiles, messages, pictures, etc. The decentralized architecture was also adopted by projects such as Cityware [13] and MobiClique [4] that link the Facebook profile to one or more Bluetooth IDs and display user's encounters. Finally in [14], Sapuppo evaluates the users' satisfaction of sociable opportunistic networks, implemented as a mobile application called Spiderweb. Test users approved the idea OSN services in physical meetings - they enjoyed the feeling of having "social networks in the air".

3. Local Social Networks

Local Social Networks (in the following referred to as LSNs) is based on integration of OSNs and ONs. This solution attempts to address sociability issues by providing a controlled automated communication system, applied in everyday physical world. As a result, the value of social networking is significantly enhanced and benefits are available immediately upon demand. Specifically, when LSNs users opportunistically encounter each other, even if they do not personally interact, their mobile phones do. They exchange users' personal contents in order to create new relationships and consequent opportunities. Following we define LSNs:

Definition: *A local social network is a wireless network of opportunistically connected sociable nodes.*

LSNs, in other words, is a distributed network architecture in which nodes are linked to online social networking profiles and wirelessly interconnected to exchange personalized contents. The communication range between the sociable nodes is direct, i.e. without passing intermediary entities, and limited to the

[4] http://www.aka-aki.com

walking distance. The LSNs communication system promotes social face to face interactions not only between acquaintances but as well between *people who do not know each other, but probably they should*. Thus, LSNs go beyond the OSN services on mobiles by highlighting relevant social paths between users in physical meetings that would be hidden otherwise. In the following, we are going to present the preliminary architecture and the first LSNs prototype.

3.1. Preliminary Architecture

Figure 1 shows a preliminary architecture of local social networks. On the left side of Figure 1, the OSN architecture is presented. OSNs are usually based on the classical client/server model.

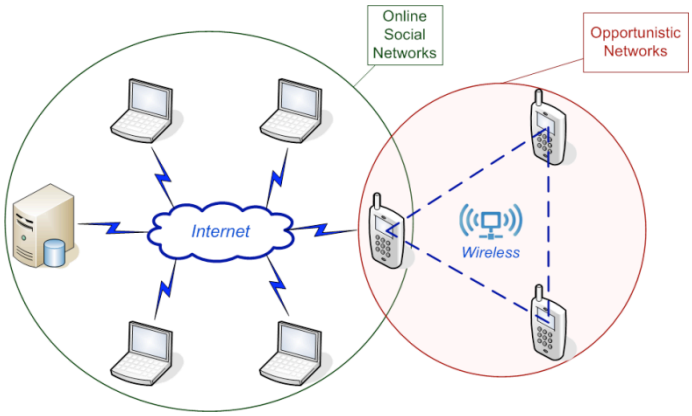

Figure 1: Preliminary architecture of Local Social Networks

The server is connected to a database that contains all the information regarding the users of the application: user profiles, messages, contact invitations, relationships between the users, etc. All the other elements are an assortment of clients. A client is able to interact with the server starting a communication through an IP bearer technology. On the right side of Figure 1, the ON architecture is presented. The architecture of ONs is based on the wireless communication and does not present any central server.

The main difference between OSNs and ONs is evident: the range where social networks are established. Regarding OSNs, usually, the amount of data is vast and therefore it may be difficult to find the needed information. In case of ONs this amount of data is restricted to the range of the wireless technology adopted. This range has to be short enough to ensure that users are in the proximity of each other. At the same time it has to be long enough for users to scan without being noticed [7]. Figure 2-A shows the wireless range of the user, however in reality the communication range is not an ideal circle due to communication signal interferences with the surroundings [9]. Within the wireless range, users are able to instantly discover each other and exchange personal contents (e.g. profiles, messages, etc).

In Figure 2-B, the device at the centre of the circle discovers the other users in his proximity and a direct connection between these two users is now possible. The device outside the wireless range is not discovered: they do not know about each other's existence and communication between these two users is not possible

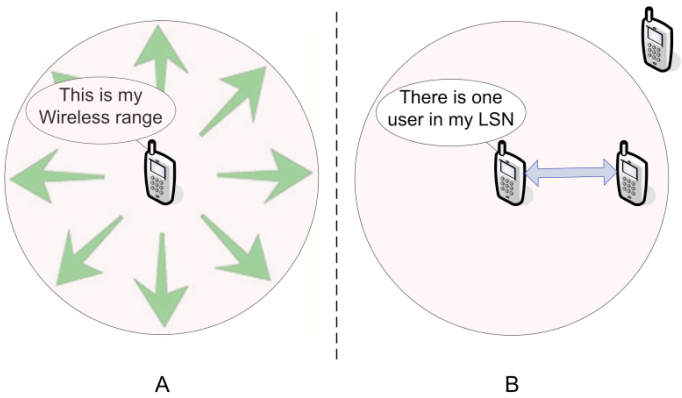

Figure 2: The range of Local Social Networks

unless they move into the wireless range.

In Figure 1, the mobile phone in the intersection space between the OSNs and ONs implicate that a LSN node can act as OSN node and ON node at the same time. The LSN node architecture is presented in Figure 3. The bottom layer of the LSN node architecture manages the communication matters. While an IP bearer technology can be used to access benefits of the OSN services, the exchange data communication is used to enable direct communication in a short range of the selected wireless technology. The node discovery and environment discovery are adopted to define the current surroundings of the user, respectively other nodes in the user's LSN and context information to determine the user activity.

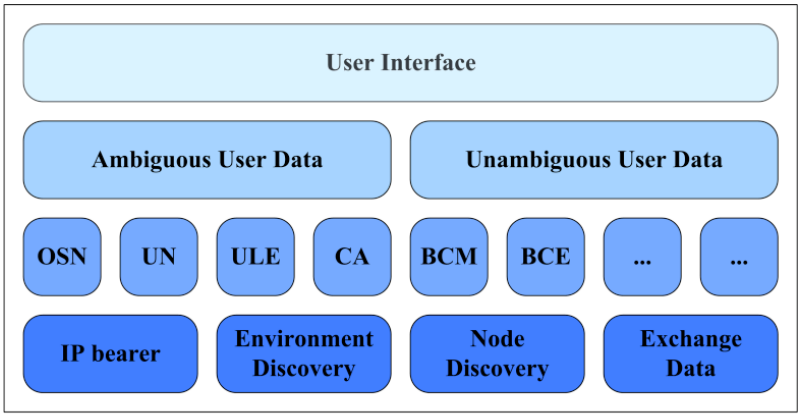

Figure 3: Local Social Network node architecture

The second layer is composed of collection of services that can be offered by LSNs, which are enabled through the bottom communication layer. They are a mix of OSNs services (e.g. find new acquaintances, search for people on the basis of certain criteria, chat, view profile of other users, etc) and others, which promote sociability in physical meetings. Particularly, the latter services such as *Business Card Management and Exchange Services* enable effective control and distribution of personalized user profiles is users' vicinity.

The profile of the user is placed in the third architecture level of Figure 3, which is divided into ambiguous and unambiguous personal data. The former one represents set of information that may be subject to continuous changes such as user preferences (e.g. food taste); the latter one is related to a set of information which does not change often (e.g. home address) and thus it is considered to be of high sensitivity. In case unambiguous data needs to be exchanged during a P2P communication, a higher security level of encryption should be considered to protect it from possible malicious observers.

Finally, the interface is placed in the top level of the LSN node architecture. The user interface has access to all the other layers of the LSN node in order to accomplish its purpose.

3.2. Spiderweb

An example of LSNs prototype is the Spiderweb application [14], implemented in Java 2 Micro Edition. Spiderweb integrates OSNs and ONs to promote flexibility and sociability of OSN services in physical meetings. The application follows the software architecture schema described in Figure 1, thus a Spiderweb node behaves as OSN node and ON node at the same time. The user profile is stored in an online social network in order to provide OSNs services, similar to the ones already available on the web (e.g. on Facebook, MySpace) and have them available while on the move. Additionally, a sub-profile of the user, which is called business card (in the following referred to as BC), is stored in the local memory of the mobile phone. The BC represents a partial identity of the user and it is shared with other users in offline mode within the range of the wireless technology adopted. In case of Spiderweb, the selected wireless technology is Bluetooth. Within the Bluetooth range, users of the application are able not only to exchange their BCs, but

also messages, contact invitations, list of friends, etc. Such services have the target to promote sociability in physical meetings. For more details about online and offline Spiderweb services refer this video[5].

The Spiderweb node is similar to the node architecture proposed in Figure 3. However, some components and services related to the automated creation of users' BCs have not been implemented yet (e.g. Environment discovery, Business Card Management services, etc). Spiderweb users exchange a static BC, which is composed of: username, gender, city, country and picture of the user. The static BC is considered to be sensitive data that users accept to share with strangers, however in case of friendship relations users can share even more data of their profile. Indisputably, sharing more user data also with strangers would surely be of high significance for discovering further networking opportunities, but in case of Spiderweb it was not taken into consideration due to expected user privacy threats. In the following section of the paper, we further explore the possibility to share extended set of user data with strangers by automated creation of different BCs of the user while preserving his data privacy.

4. Privacy on Local Social Networks

Privacy has always been a subject of public attention and, recently it was identified as one of the main issues of OSNs. When OSNs users communicate, find new friends, post messages or pictures, they also reveal sensitive information to the web. Previous studies have shown that personal data of users is munificently provided in OSNs by adding users as friends without hesitation, while security settings are rarely used [15] [16] [17]. In order to enable enhanced data protection, OSNs promote new possibilities to group friends into different categories associated to different levels of trust. However, LSNs present additional privacy issues due to the support of interaction with strangers in physical world [9] [18]. Particularly, users of LSNs constantly have to disclose their current location as well as personal information in opportunistic meetings. Following we discuss privacy advantages of the LSNs architecture in regard of sharing of user location. Afterwards, we address privacy issues caused by the sharing of personal information in physical meetings through introduction of a new concept called Diverged Personalities.

4.1. User location

Sharing of user location is one of the main characteristics of mobile social networks, which enables location based services (in the following referred to as LBS). LBS helps users to connect to friends, be alerted when they are close and discover places around them by sharing the users' GPS positions [19]. However, location is considered to be very sensitive information, thus important privacy issues arise and LBS users must put great trust in order run such services [20].

LSNs present added value for solving LBS privacy issues by locating people exclusively within the range of the adopted wireless technology. Particularly, LSNs users are notified about the presence of other users only when they are in the vicinity. Thus, once the nodes move away, the location information is not available anymore, unless they re-enter into each other's wireless range. As a result, the minimization of risks related to user location sharing will lead to positive trade-off between potential benefits and threats.

4.2. Diverged Personalities

As discussed previously, the foundation of LSNs is sharing of personal information in the physical world. Surely, the amount of information disclosed is directly proportional to LSNs benefits. The optimal outcomes would be provided by sharing as much as possible personal information (e.g. full user profile). However, this would result in jeopardy of users' privacy and a compromise is necessary. It can be achieved by the following assumption: the sensitivity of the users' personal information is not stable; it may vary depending on activities and interactions in which the user is involved. Consequently, only the information that is relevant however not sensitive in those circumstances should be disclosed at a time.

For instance, in an IT work environment, we assume that the user wouldn't like to share political preferences with strangers, and on the other hand he would like to share professional abilities, such as

[5] http://www.youtube.com/watch?v=DgeVNv10CIM

programming skills. In this example, the programming skills are assumed to be not sensitive, but relevant information due to the logical and natural connection between IT work environment and IT skill. On the contrary, political preferences are not relevant and even more importantly could be treated as sensitive data of the user under those specific circumstances. In comparison, professional abilities would not be shared while relaxing in a bar, but music taste or relationship status could be relevant due to potential topic for interaction with strangers. Based on the previous examples, the users should be represented by different personalities in different situations. Thus, we refer to user's diverged personalities (in the following referred to as DiP).

DiP is inspired by the Portable Personality (in the following referred to as P2) project. P2 focuses on acquisition and management of user profiles via mobile devices [21]. P2 targets to enable personalization of services by collecting data from the digital and physical world in order to digitalize the users' personality in a unified user profile [22] [23] [24]. DiP goes beyond the P2 concept: the unified user profile is diverged in digital sub-profiles that represent the current personality of the user at a point of time.

In LSNs, a personality of a user is a set of user's personal information, which is utilized to facilitate safe communication in LSNs. Thus, a user shares different personalities in different circumstances. The most suitable user's personality is generated by the process shown in Figure 4.

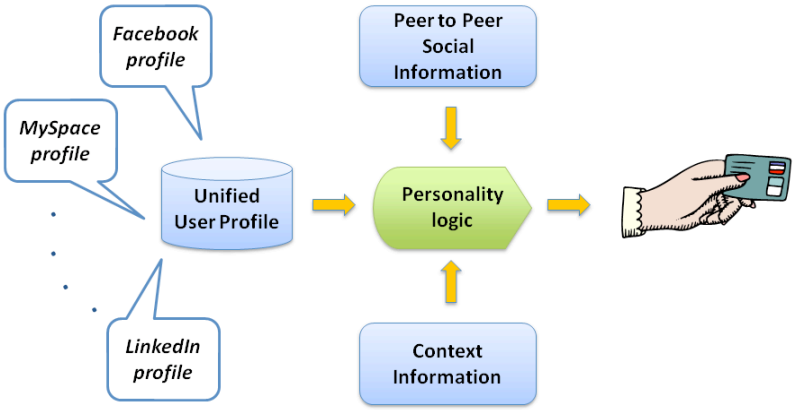

Figure 4: Diverged Personalities components

The central component of the diverged personalities is the *Personality Logic*. The personality logic receives as input the unified user profile, the type of social interaction between the users and information about the environment. Based on this data, algorithms will provide the best personality match for those circumstances.

The first step of DiP is merging different profiles into a *Unified User Profile*. The unification of user profiles, as previously mentioned, has been already explored in regard to the P2 concept. Moreover, it was also discussed as a necessary OSNs development target due to numerous existing OSNs user profiles [25]. This leads to data portability issues which are addressed by projects such as Open ID[6] and FOAF[7].

In LSN, *Peer to Peer Social Information* can be classified in two main categories: friends and strangers. Naturally, the former category receives more privacy permissions than the latter one. Regarding the friends category, LNSs follows new privacy protections already applied in OSNs. Thus, different levels of trust will be granted to different groups of friends. On the other hand, generally, strangers are usually able to access only limited public profiles. However, LSN promotes the interactions between strangers in the user proximity, as long as it does not affect the users' privacy. We decided to add a new group of strangers in LSNs, called familiar strangers: two people are classified as familiar strangers if they encounter regularly without interacting or forming an explicit relationship of a social nature [26] [27]. Upon demand, familiar strangers might receive additional permissions to access personal data in comparison to strangers. Thus,

[6] http://www.openid.net
[7] http://www.foaf-project.org

LSNs would show relevant connections between people and consequently possible solutions that have been always close but never visible.

The last input data of the Personality Logic is the *Context Information*. Context is any information that can be used to characterize the situation of nodes participating in local social networks [28]. It may be collected by data from calendars, multiple sensors in order to represent the users' environmental surroundings, etc. Thus, context examples are location, time, activities that a person is engaged in. The context information tries to answer simple questions such as: What is the user doing? In which environment is the user acting?

Once the Personality Logic processes all the information received, a single personality at a time will be chosen. The *Selected Personality* is a set of relevant personal information, similar to a business card. The chosen business card will be shared with a specific node of the local social network. It varies depending on the context information and types of social interactions with other peers of the network.

Finally, in order to protect the user data better, we note that the interaction between LSN users is enabled only through direct links, i.e. without any intermediaries. However, DiP cannot completely guarantee user data privacy in local social networks. A hypothetical attacker, who would like to take advantage of the DiP model, should own several mobile devices with different fake profiles and always stay within the vicinity of the victim by following him in all his activities (e.g. at work, home, holidays, etc). This behaviour would be able to break the DiP privacy protection model. However, we believe that this scenario is highly unlikely and the benefits of LSN significantly exceed the risks.

5. Conclusions

In this paper we presented a new communication system called local social networks which is based on integration of OSNs and ON. LSNs target at improving sociability in physical meetings, while taking into consideration all social interaction types. Particularly, the LSNs promote interactions with strangers in order to exploit potential networking benefits, which arise due to uncovered social connections that were previously hidden. Naturally, social interactions must be based on disclosure of private information, which consequently leads to potential privacy concerns. In this paper, these issues are attempted to be addressed through the introduction of a new concept, called Diverged Personalities. Based on DiP, users do not share neither a full profile nor a static sub-profile in their vicinity. Instead, they share a personality of the user which varies according to different conditions. The selected personality is composed of personal user data that is relevant, however not sensitive in those circumstances.

In future work, a deep study of possible applications of DiP is necessary, followed by a user tests to determinate validity and acceptance of DiP. Finally, an extended LSNs prototype will be implemented by enabling the exchange of BCs based on diverged personalities of the users.

Acknowledgments

This work is supported by Nokia and developed as a part of the Converged Advanced Mobile Media Platforms (CAMMP) project[8]. The authors would like to thank Boon-Chong Seet for his valuable comments.

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